(12) UK Patent Application (19) GB (11) 2 120 692 A

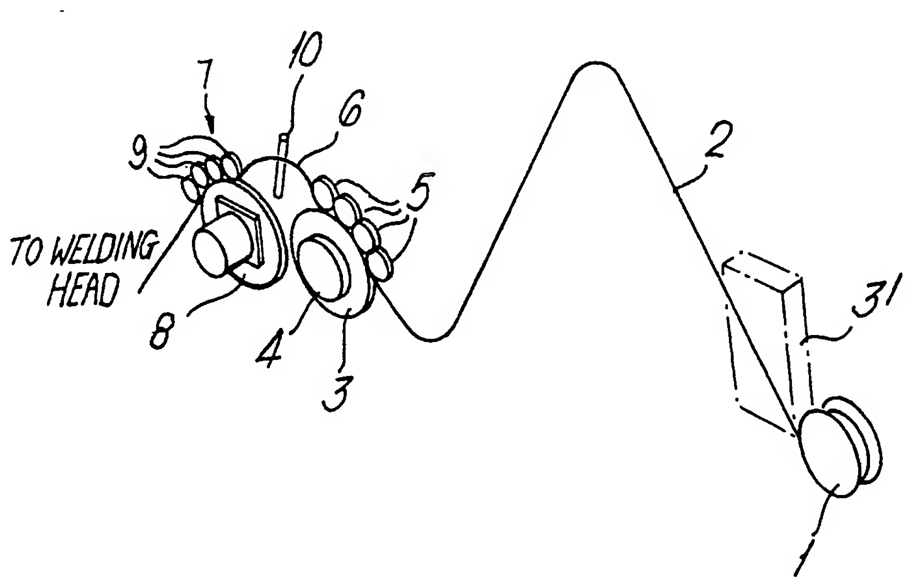
(21) Application No 8313455
(22) Date of filing 16 May 1983
(30) Priority data
(31) 8214059
(32) 14 May 1982
(33) United Kingdom (GB)
(43) Application published
7 Dec 1983
(51) INT CL³
B65H 59/00 B23K 9/12
(52) Domestic classification
D1J E
B3R 32D2 36 37A1A
37A1D 37A1E
U1S 1673 1969 B3R D1J
(56) Documents cited
GB A 2084618
GB 1578860
GB 1316817
GB 1176589
GB 1036452
GB 0932909
GB 0820097
GB 1490293
(58) Field of search
D1J

(71) Applicants
The Welding Institute,
(United Kingdom),
Abington Hall,
Abington,
Cambridge,
CB1 6AL,
Northern Engineering
Industries plc,
(United Kingdom),
NEI House,
Regent Centre,
Newcastle upon Tyne,
NE3 3SB
(72) Inventor
Dr Kenneth William
Brown
(74) Agent and/or address for
service
Gill Jennings and Every,
53—64 Chancery Lane,
London,
WC2A 1HN

(54) Improvements relating to wire supplying

(57) Apparatus for supplying wire (2) to an arc welding site comprises an electrode wire store (1), a capstan feeder (3) driven by an analogue drive (not shown) for drawing wire from the store (1), and means (not shown) for guiding the wire drawn from the store around a reserve loop 6. Decrease in loop size is sensed by element 10 to increase the speed of capstan feeder 3.

Fig. 1.



GB 2 120 692 A

2120692

1/6

Fig. 1.

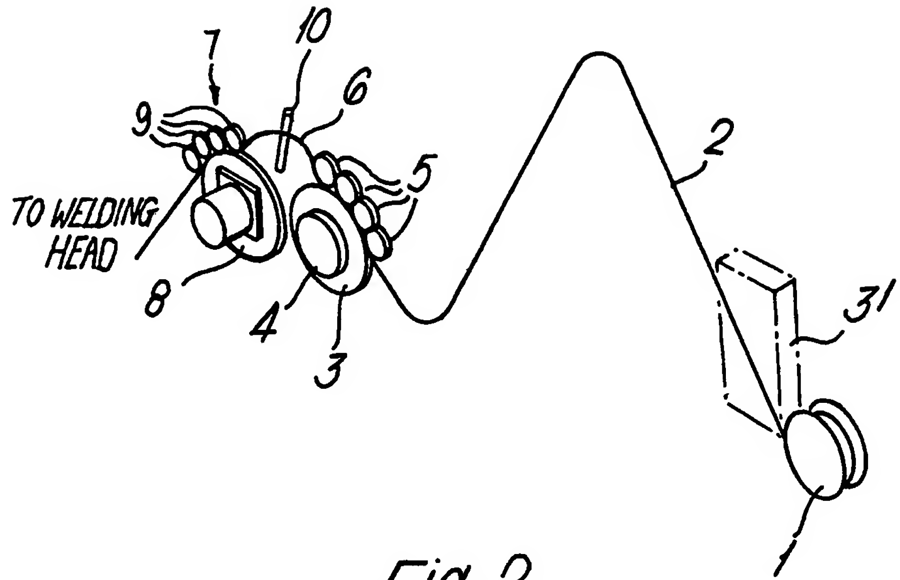


Fig. 2.

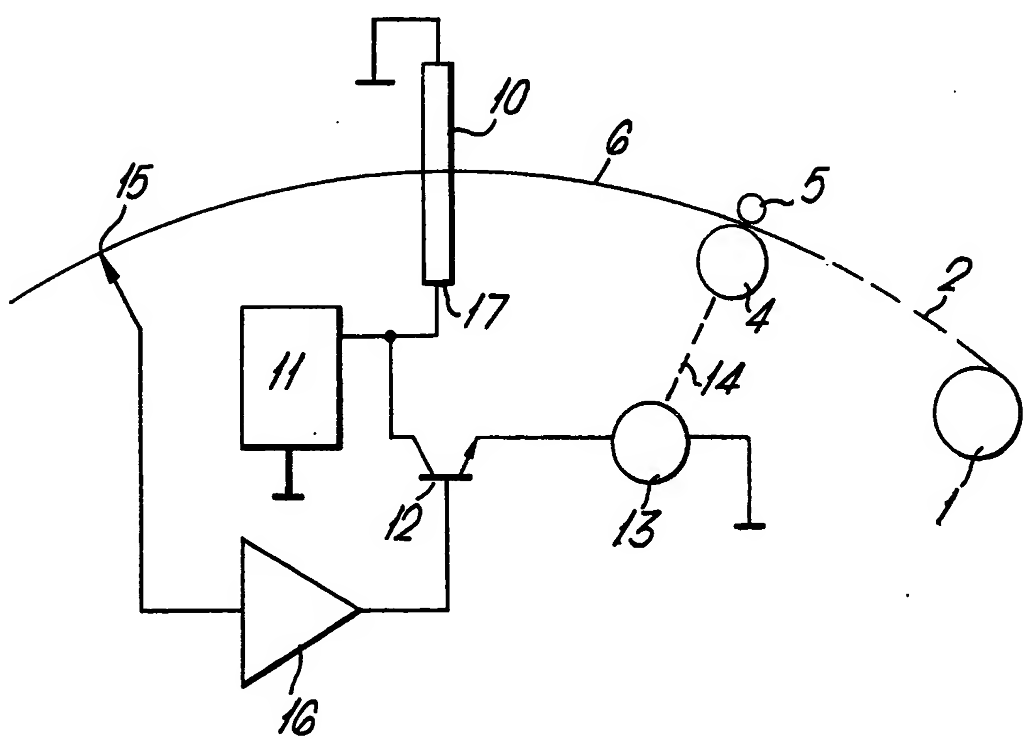
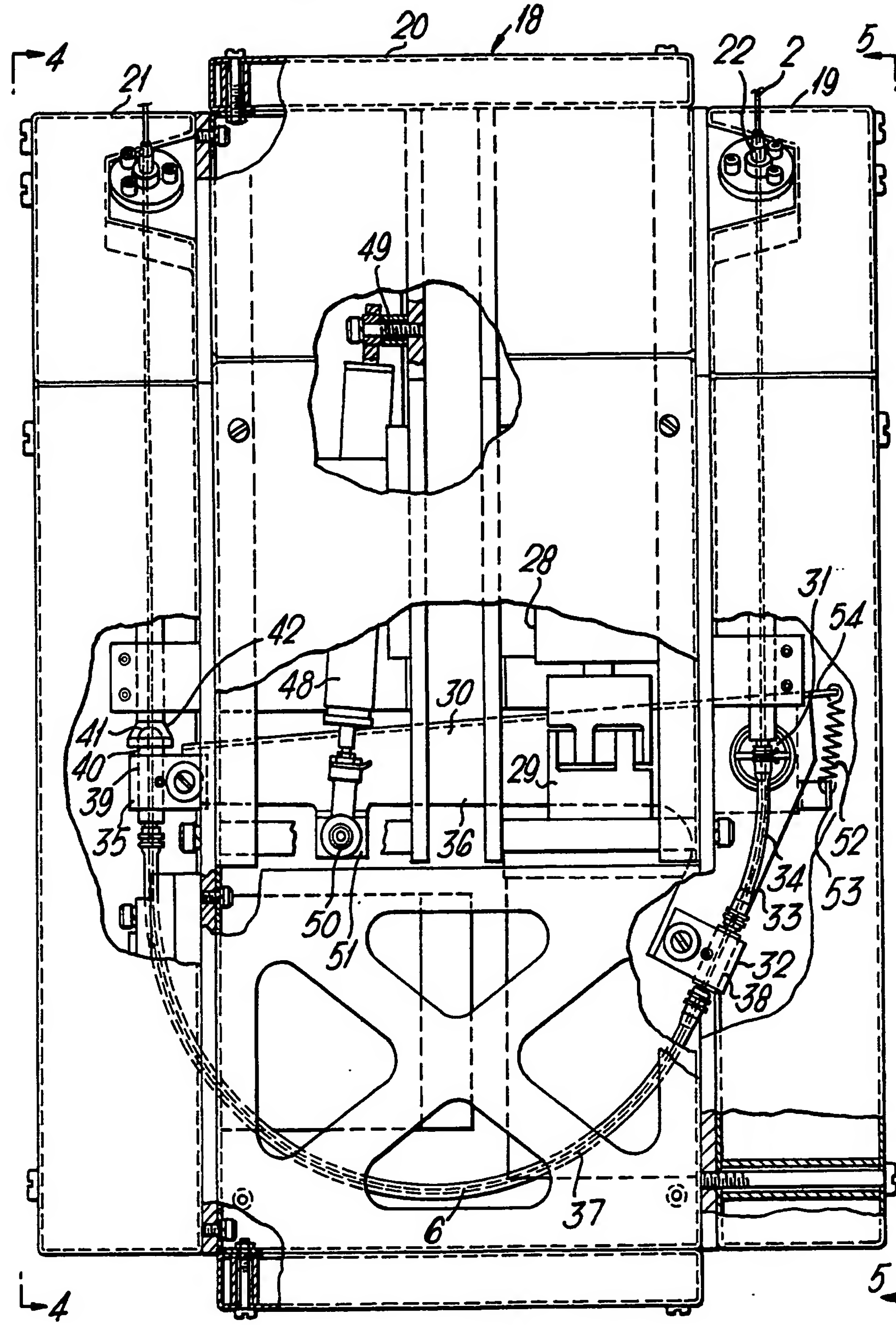


Fig.3.


4
4
5
5
20
18
21
22
2
19
49
28
42
48
30
31
54
41
40
39
35
29
36
52
34
53
33
50
51
32
38
6
37

2120692

Fig. 4. 3/6

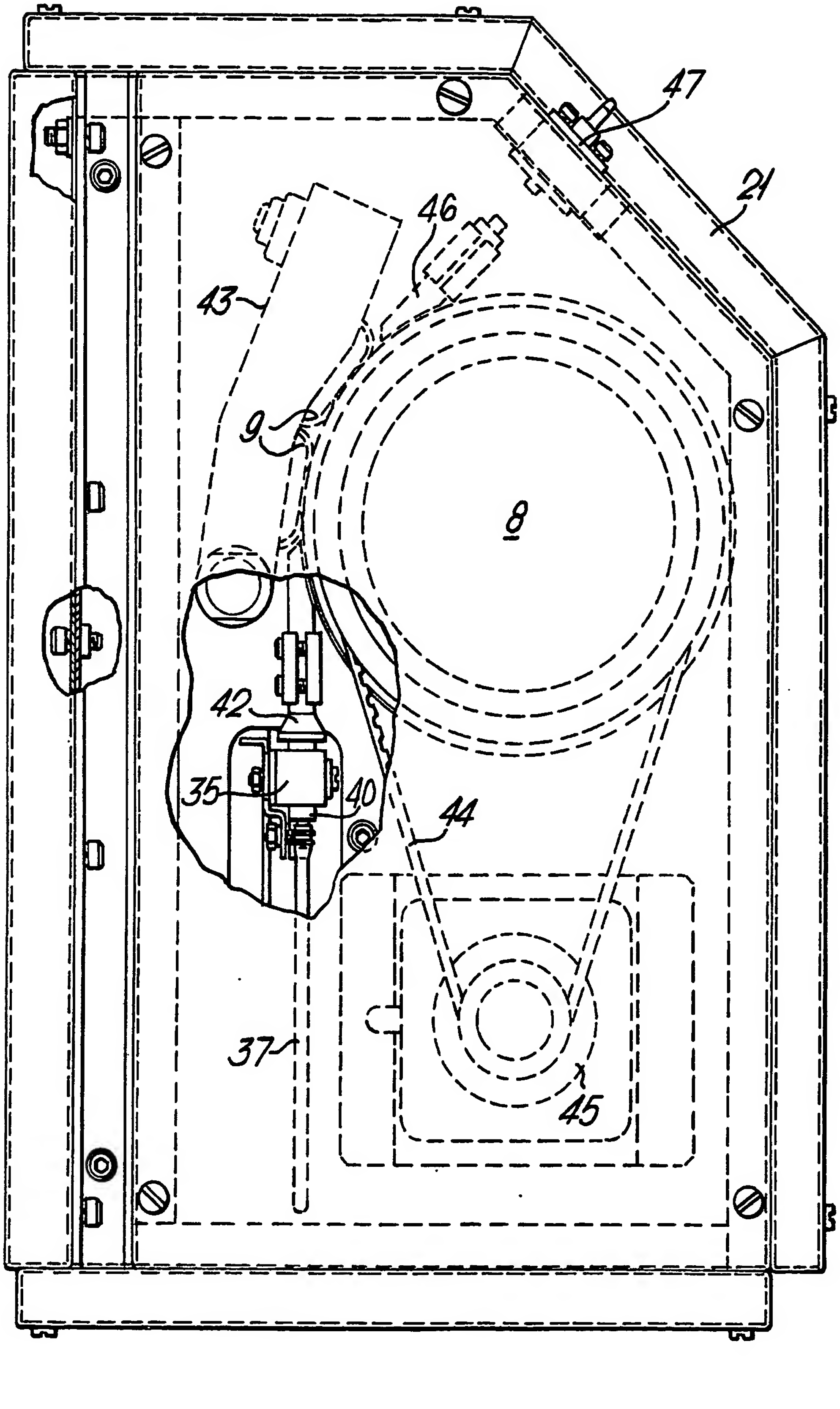
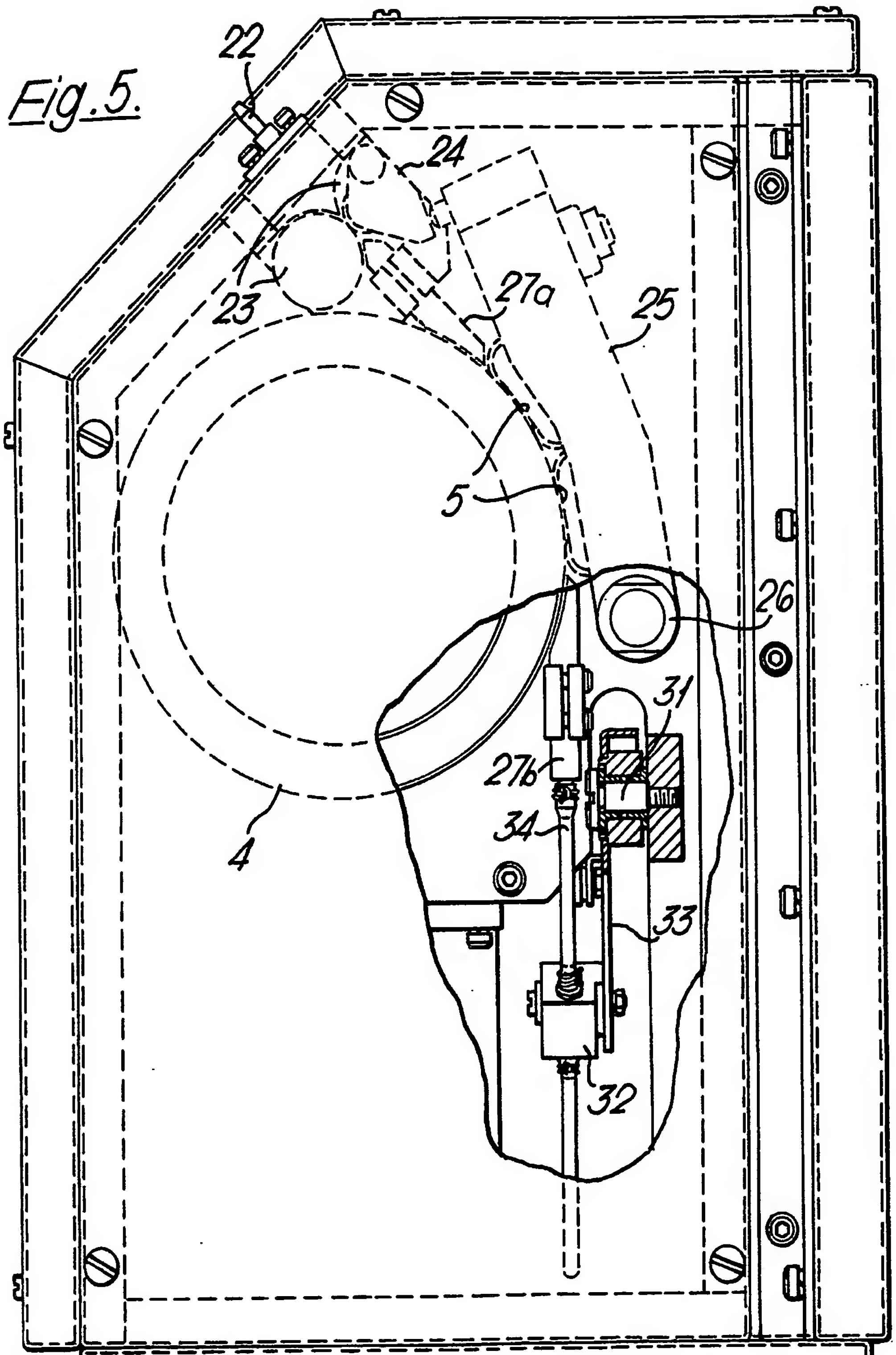


Fig. 5.



BEST AVAILABLE COPY

2120692

Fig. 6.

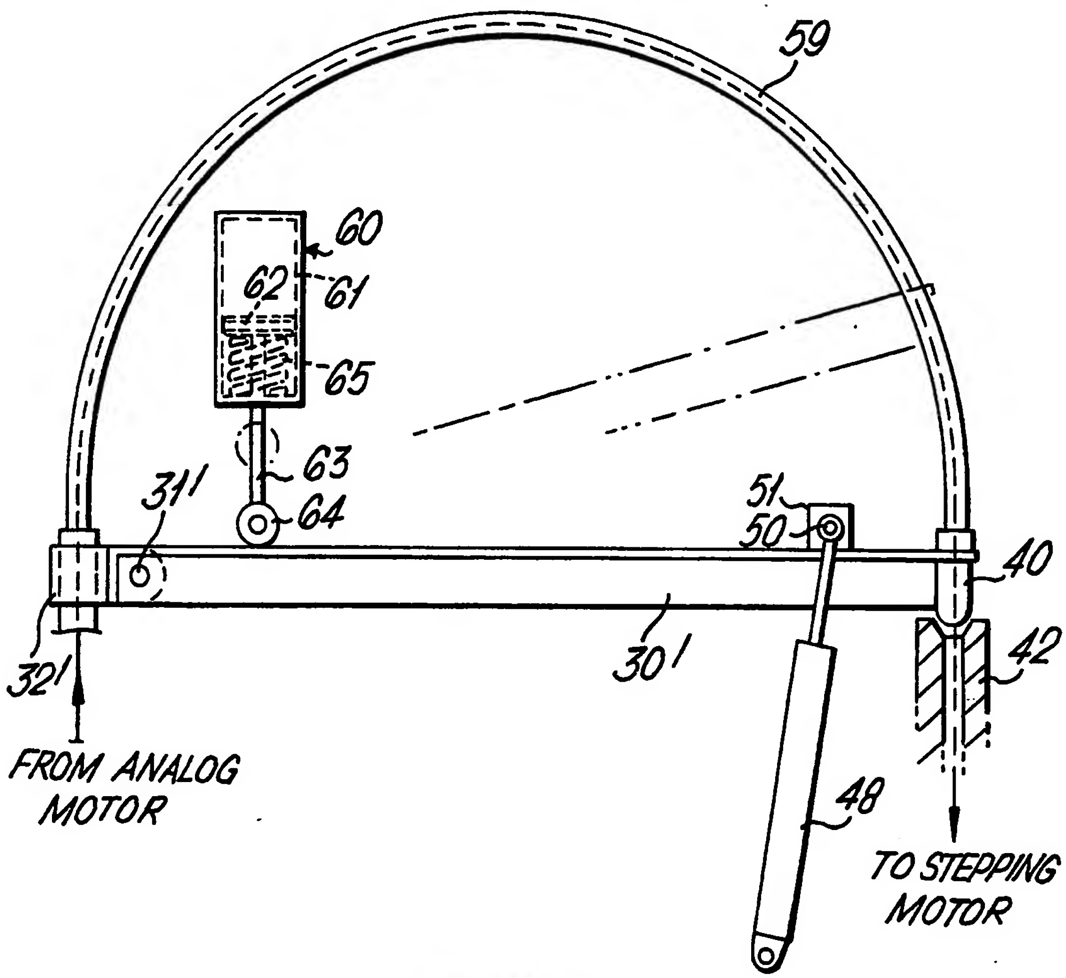


Fig. 7.

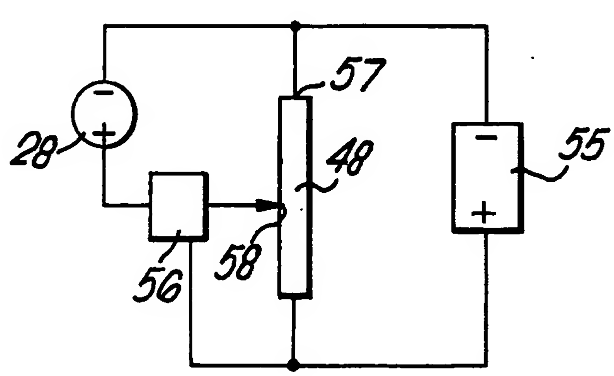


Fig. 8A. 6/6

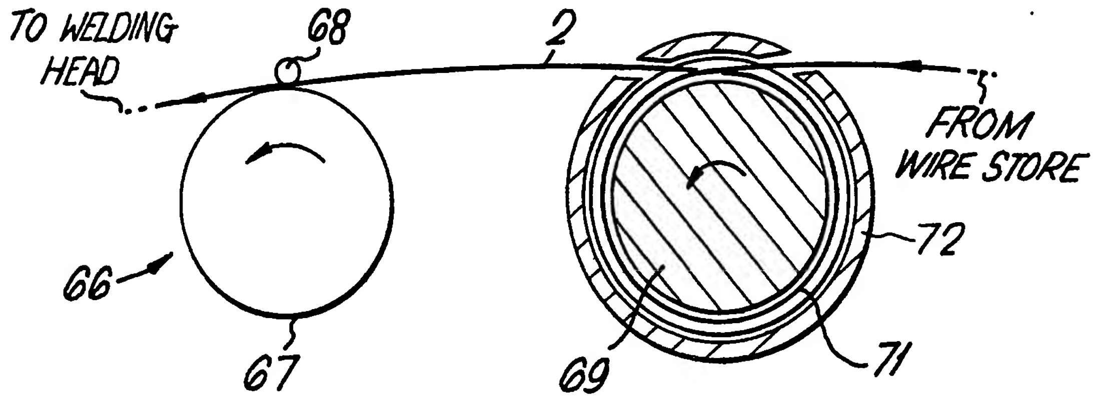


Fig. 8B.

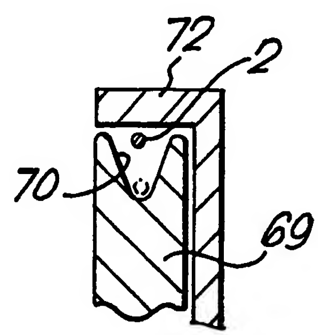
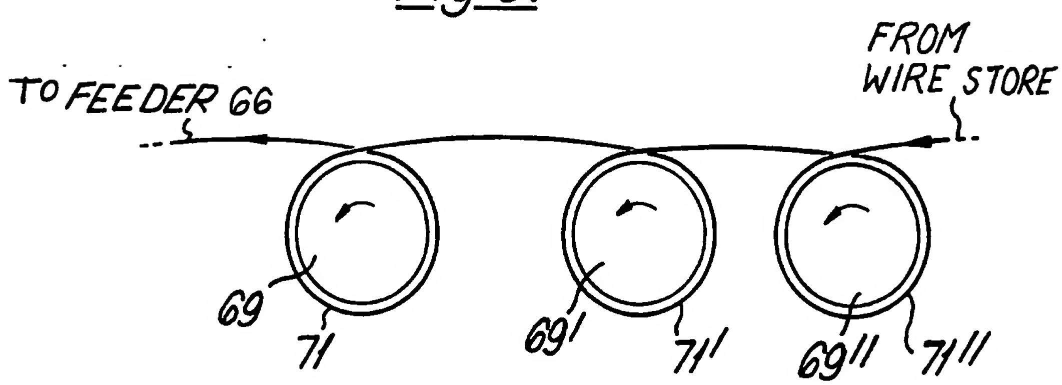


Fig. 9.



SPECIFICATION

Improvements relating to wire supplying

The invention relates to methods and apparatus for supplying wire from a store to an arc welding site.

The requirements for supplying electrode wire to the arc welding site differ depending upon the particular type of welding method involved. One problem which arises in many welding methods is that wire is commonly drawn from a rotary store such as a spool and the inertia of the store varies considerably during use. Also, it is often necessary to accelerate or decelerate the feed to an arc welding site and if this is carried out too quickly, and without effective retardation of the store, the wire will buckle and kink. This problem is becoming more important in the field of continuous welding where a large wire store is required and consequently the inertia of the store when full is high.

Another problem with wire feed systems is in the selection of an appropriate driving mechanism. In general, the quality of a feed is judged in relation to both its consistency and accuracy. A consistent feed means that there is little chance of the wire buckling or kinking and can be obtained by using slip-free wire feed rolls powered by a conventional analogue drive. This provides a consistent feed which can even include a sinusoidal modulation. A more accurate system may be obtained by the use of a step drive such as a stepping motor or nip feeder which advances the wire in a series of defined discrete steps. This should enable the feed rate and the amount of wire fed to be accurately determined but in practice only if slip-free feeding is ensured. Furthermore, a step feed is inherently not smooth and although very rapid acceleration and deceleration may be achieved this can be accompanied by buckling and kinking of the wire, due, for example, to the inertia of the rotary store from which the wire is drawn.

Such problems as those outlined above arise in for example MIG welding where at start up it is desirable to retract the electrode wire immediately after short-circuiting in order to assist initiation of the arc. Various complex methods have been proposed in the past to achieve this such as that described in an article entitled "Improvement of Gas Metal-Arc Spot Welds" by S. A. Agnew and W. N. Canulette in the April 1964 edition of Welding Research Supplement. In that proposal, a planetary gear arrangement is used to achieve retraction, which is complex and undesirable.

Another important area in which these problems arise is that of spacer welding. In the manufacture of heat exchangers, particularly for use in nuclear power stations, adjacent tubes of the heat exchanger are supported and kept at the correct distance from each other by small spacers welded to the tubes. The welds must be very precisely formed in order to maintain the flow characteristics of the heat exchanger and so an extremely accurate feeding arrangement is required. However, in the case of such heat exchangers a very large number of welds need to be made and it is desirable for this to be substantially automatically carried out. In the past, due to the skill required, manual welding has been necessary. For automatic welding, a continuous supply of electrode wire is desirable but in view of the precision needed, including rapid start and stop this has not previously been achieved since only a step drive will provide that precision.

In accordance with one aspect of the present invention, a method of supplying wire from a store to an arc welding site comprises forming a reserve loop in the wire between the store and the welding site; and supplying wire from the store when the size of the reserve loop decreases in response to demand for wire at the arc welding site.

In accordance with a second aspect of the present invention, apparatus for supplying wire to an arc welding site comprises an electrode wire store; and supplying means for supplying wire from the store, a part of the wire supplied from the store describing a reserve loop in use, whereby the supplying means supplies wire from the store when the size of the reserve loop decreases in response to demand for wire at the arc welding site.

One of the most important advantages with the provision of a reserve loop in the wire path is that rapid and accurate acceleration/retardation of the wire feed immediately adjacent the arcing location is possible. Furthermore, the problem of the inertia of the wire store is substantially overcome since the loop allows a rapid acceleration of the wire at low drive motor power, independently of the store. Thus, if a continuous feed is suddenly stopped, instead of the wire simply buckling, the extra wire fed from the store due to its inertia will be conveniently accommodated by an increase in size of the reserve loop. Similarly, a sudden acceleration will cause a corresponding decrease in the size of the reserve loop without any breakage of the wire.

This ability for rapid acceleration/retardation is particularly useful in the cases of short precision welds including tack welds; intermittent feeds of filler wires in for example TIG or plasma welding, pulsed wire feed in MIG welding, and retract starting in MIG welding which avoids heavy initial short circuit currents. In conventional systems, such retraction would result in back-load buckling of the wire unless the continuous feed from the store could be halted or reversed. This ability to retract enables the apparatus to be utilised in an automated system with the various stages pre-programmed. Furthermore, this is one reason why simply substituting a large stepping motor for the conventional analogue motor would not be satisfactory. Although such a motor could possibly overcome the various inertial problems, it would not be able to facilitate rapid reversals of the wire in the delivery conduit.

We have found that with our invention, it is

possible to start or stop the electrode wire feed at the arc welding site in less than 0.01 seconds irrespective of the size of the wire store.

Preferably, the method further includes sensing the size of the reserve loop and controlling the rate at which the wire is supplied from the store in response to the sensed size of the loop. This feature is also useful for semi- or fully automatic welding where such feeback is used automatically to control the wire feed rate from the store.

Various methods of sensing the size of the reserve loop loop may be used. In one mechanical arrangement, the wire may be caused to run over a wheel on the pivoted arm, the position of the arm being sensed. One problem with such an arrangement is that if there were a sudden acceleration in the wire feed speed, a slow response of the arm/wheel arrangement could cause kinking.

An alternative arrangement is to provide a plurality of sensors, such as light emitting diodes and transistor switches, in a line in the same plane but transverse to the reserve loop. These sensors would then detect the reserve loop of wire as it passed over them and hence indicate the size of the reserve loop.

In one example, the apparatus may comprise a resistive element against which the reserve loop of wire is caused to rub in use, the resistive element being electrically connected to the means for supplying wire from the store, the means for supplying wire from the store being electrically connected to the electrode wire at a position spaced from the resistive element whereby a variable resistor or potentiometer is formed by the wire and the element, the position of the wire on the element determining the effective resistance or potential of the variable element and thereby controlling the speed of the means for supplying the wire from the store. This provides a very simple method of determining the position of the reserve loop and has the advantage that the position is instantly determined on start up, is known continuously and accurately in use, and does not cause the wire to kink. Also, the rubbing of the electrode wire against the resistive element can have a self-cleaning effect.

In another example, at least a portion of the reserve loop passes through a conduit which is movable in response to changes in the size of the reserve loop, the conduit being coupled to means for sensing its position whereby the size of the reserve loop is sensed. With this arrangement, the conduit, which may be made of a plastics material, may be coupled to a transducer such as a potentiometer, the output of which is coupled with the means for supplying wire from the store. Conveniently, the conduit is tubular so that movement of the reserve loop in any direction is detected by the conduit and hence passed to the transducer.

In one particularly convenient arrangement, the apparatus comprises a continuous drive, for example an analogue drive, for supplying wire from the store; and a step drive for feeding wire to the welding site, the reserve loop being provided between the continuous drive and the step drive, with this arrangement, the advantages of each type of drive are utilised. Wire is supplied smoothly from the store by the continuous drive and fed accurately to the arc welding site by the step drive. There is no need for accurate synchronisation between the two drives, the continuous drive being able to overrun or lag the step drive within the limits provided by the reserve loop. For example, this allows a reduction of the response of the continuous drive to worse than 0.1 seconds, while the step drive has a response better than 0.01 seconds for wire supply speeds up to at least 20 m/min. Furthermore, this enables high speed stepping motors to be used which can provide up to 1000 half steps per revolution, possibly in combination with gearing providing a reduction of some 3 or 4 to 1, in the case, for example, of a wire drive roll of some 150 mm diameter.

The arrangement outlined above utilising a continuous drive and a step drive is particularly applicable for automatic welding where the step drive is supported on a robot arm. This enables the low torque step drive motor to be positioned close to the arc welding site on a manipulatable part of the robot arm.

Preferably, each drive comprises a pinch roll feeder of the type described in British Patent Specification No. 1,217,174 to minimise slip, although the analogue drive could be provided by conventional drive roll systems, reciprocating electromagnetic solenoids, linear grip drives, capstan feeders and the like.

A further important advantage of this arrangement is that the step drive does not have to pull wire directly from the store, the large forces required to achieve this being overcome by the continuous drive allowing the step drive to perform as accurately as possible, minimising wire slip in the step drive, and enabling very precise welds to be achieved.

In one preferred construction, the above arrangement utilising a continuous drive and a step drive is also provided with the conduit through which the reserve loop passes, the conduit being pivoted at one end and being movable to a first position so that on start up wire may be fed automatically from the continuous drive to the step drive, the conduit subsequently being pivotable away from its first position in response to changes in the size of the reserve loop. In this case, the conduit serves a dual purpose of enabling the size of the reserve loop to be sensed and also assisting the feeding apparatus to be set up initially. As may be appreciated, this is particularly important with automatic welding apparatus and where the step drive (and possibly also the continuous drive) are positioned in areas remote from the wire store, for example on an overhead gantry. It is also useful where the apparatus is contained in a gas tight

enclosure since no access is required for loading up and threading the wire beyond the store itself.

In another example, the means for supplying the wire from the store comprises a continuous drive positioned adjacent the reserve loop, the arrangement being such that when the size of the reserve loop decreases in response to demand for wire at the arc welding site, the reserve loop engages the continuous drive whereby wire is drawn from the store. This example is different from the previous example since the continuous drive is adjacent the reserve loop and the necessity to sense the size of the reserve loop is avoided. Thus, when electrode wire is demanded at the welding site the reserve loop will decrease until it engages the continuous drive (at which point the reserve loop may temporarily cease to exist), and wire will be drawn from the store by the continuous drive. If that wire is not immediately required at the arc welding site, the reserve loop will reform and the wire will cease to engage the continuous drive and the wire will no longer be drawn from the store. Even where a rotary store is provided which continues to rotate due to its inertia, excess wire will simply be accommodated in the reserve loop as in the previous example.

Preferably, in the above example, the means for drawing wire from the store comprises a plurality of continuous drives, the electrode wire being guided through a corresponding plurality of reserve loops adjacent respective ones of the drives. This is particularly useful where there is a long distance between the wire store and the arc welding site.

Conveniently, the or each continuous drive has a V-shaped driving surface which engages and guides the wire in use. This is useful to prevent the reserve loop from moving so far away from the or each continuous drive that on subsequently decreasing its size it will not engage the drive.

Preferably, the or each continuous drive comprises a capstan feeder, the reserve loop being formed around the capstan of the capstan feeder.

Some examples of methods and apparatus in accordance with the invention will now be described with reference to the accompanying drawings, in which:—

Figure 1 is a schematic view illustrating the principle of one example;

Figure 2 is a schematic diagram of circuitry for use with the example shown in Figure 1;

Figure 3 is a plan, partly cut away, of a second example;

Figure 4 is a side elevation taken on the line 4—4 in Figure 3;

Figure 5 is a side elevation taken on the line 5—5 in Figure 3;

Figure 6 illustrates a modification to the example shown in Figures 3 to 5;

Figure 7 is a schematic diagram of circuitry for use in the example shown in Figures 3 to 6;

Figure 8A illustrates diagrammatically a third example;

Figure 8B is a partial cross-section through the analogue driven capstan of Figure 8A; and,

Figure 9 illustrates a modified form of the apparatus shown in Figure 8A.

Figure 1 illustrates the principle of operation of one example of the apparatus. The apparatus comprises a rotatably mounted spool 1 on which is wound a length of electrode wire 2, the spool 1 forming a rotary store. The wire 2 is guided by means not shown to a pinch roll feeder 3 comprising a capstan wheel 4 and rollers 5 which press the wire 2 against the perimeter of the capstan wheel 4. The capstan wheel 4 is connected by means not shown to a continuous or analog drive so that in operation as the capstan wheel 4 rotates wire 2 will be drawn from the spool 1.

The wire 2 is fed from the pinch roll feeder 3, via a reserve loop 6 to a second pinch roll feeder 7. The pinch roll feeder 7 is constructed in an exactly similar way to the pinch roll feeder 3 and has a capstan wheel 8 and rollers 9 mounted adjacent the perimeter of the capstan wheel 8. The capstan wheel 8 is connected by means not shown to a stepping motor which, in use, will rotate the capstan wheel 8 in a series of discrete steps.

The pinch roll feeders 3, 7 may be similar to the type described in British Patent Specification No. 1,217,174. The analogue drive and stepping motor may be of any conventional type.

The pinch roll feeder 7 draws the wire 2 from the reserve loop 6 and feeds the wire to a welding head (not shown). In practice, the welding head may be located on a robot arm while one or both of the pinch roll feeders 3, 7 may also be mounted adjacent the robot arm, for example on either side of the robot arm pedestal, or the feeders may be located in a more remote position from the welding head. Figure 1 illustrates an alternative position 3′ for the pinch roll feeder connected to the analogue drive although the reserve loop 6 may still be positioned adjacent the pinch roll feeder 7.

The reserve loop 6 is caused to rub against a resistive element 10 made, for example, from nichrome wire, connected in electrical circuitry to be described below. This arrangement allows the decrease in size of the reserve loop 6 to be sensed.

Figure 2 illustrates diagrammatically circuitry for sensing and controlling the size of the reserve loop 6. The circuitry comprises a power source 11 connected in series with one end of the nichrome wire 10 which is connected to the collector of a transistor 12. The emitter of the transistor 12 is connected to the armature of the analogue drive 13. A dashed line 14 represents the connection between the analogue drive 13 and the capstan wheel 4. A conventional electrical sliding contact 15 contacts the electrode wire 2 downstream of the resistive element 10 and is connected with a buffer amplifier 16 the output of which is connected to the base of the transistor 12.

In operation, if the reserve loop 6 should decrease in size (i.e. move downwards in Figure 2) due to the demand rate of the pinch roll feeder 7 exceeding the supply rate of the pinch roll feeder 3, the resistance provided by the resistive element 10 between that part of the reserve loop 6 which rubs against the element 10 and the point 17 will decrease. This will cause the voltage applied to the base of the transistor 12 to increase and hence the supply to the armature of the motor 13 will increase. This will cause an increase in the speed of the motor 13 and hence in the rotation speed of the capstan wheel 4 until electrode wire 2 is supplied to the reserve loop 6 at a rate faster than it is removed by the pinch roll feeder 7 to enable the reserve loop 6 to be restored towards its original position. Conversely, if the reserve loop 6 increases beyond an equivalent equilibrium position, the potential provided by the resistive element 10 will decrease causing a decrease in rotation speed of the capstan wheel 4. As will be appreciated, this is a continuous process, the speed of the analogue motor 13 being continually adjusted in order to maintain the size of the reserve loop 6 around an equilavent equilibrium position.

In practice, it is preferable that the maximum speed of the analogue motor 13 exceeds the maximum speed of the stepping motor. However, if the stepping motor is used at an intermittent speed, for example 10 m/min for 0.6 seconds (100 mm bursts) with an off period of nominally zero feed for 0.9 seconds, then the maximum speed of the analogue motor 13 need only exceed the mean output speed, that is 4 m/min (100 mm in 1.5 seconds).

The example illustrated in Figures 3 to 5 shows a compact, self-contained feed unit which can be positioned remotely from an electrode wire store since it has a self-feeding capability. The unit comprises a housing 18 formed of three sections 19, 20, 21. The three sections 19—21 can be bonded, welded, or bolted (as shown) together to form the unit. An electrode wire entry port 22 is bolted to the housing 19 and is positioned to guide an electrode wire 2 between a pair of guide rollers 23 rotatably mounted in the housing 19 (Figure 5). One of the guide rollers 23 is rotatably mounted on a pivoted arm 24. The capstan wheel 4 is rotatably mounted in the housing 19 and rollers 5 mounted on a pivoted arm 25 are urged against the perimeter of the capstan wheel 4. The arm 25 which is pivoted at 26 is urged towards the capstan wheel 4 by conventional means (not shown). A guide conduit 27a is provided adjacent the guide wheels 23 to guide the electrode wire 2 between the rollers 5 and the capstan wheel 4. As the electrode wire 2 emerges from between the rollers 5 and the capstan wheel 4 it enters a guide conduit 27b.

The capstan wheel 4 is connected to an analogue drive motor 28 mounted in the housing 20. A motor 28 is connected to a conventional gear system (not shown) by a linkage 29.

A light but rigid metal bar 30 having a generally "L" shape is pivotally mounted within the housing 19 about a pivot 31. A guide block 32 is secured to an end of a short arm 33 of the bar 30 and a plastics conduit 34 extends from the guide conduit 27b to the guide block 32. A second guide block 35 is secured to an end of the long arm 36 of the bar 30 and a plastics conduit 37 is connected between the guide blocks 32 and 35. The guide block 32 has a conduit 38 in communication with the plastics conduits 34, 37 while the guide block 35 has a conduit 39 in which is located a male locating member 40. The leading end 41 of the locating member 40 is rounded so that in use as the bar 30 pivots in a clockwise direction, as viewed in Figure 3, to the position shown in Figure 3 the locating member 40 can be easily received in a correspondingly shaped female locating member 42.

As may be seen in Figure 3, the plastics conduits 33, 37 form together a substantially semi-circular path for the electrode wire 2. In practice this path is part of the reserve loop 6 described previously.

The female locating member 42 is mounted within the housing 21 and guides the electrode wire in use between the capstan wheel 8 and the rollers 9 of a pinch roll feeder substantially the same as that mounted in the housing 19. The rollers 9 are rotatably mounted on a pivoted arm 43. The capstan wheel 8 is connected by a toothed, endless belt 44 to a stepping motor 45. In operation, the stepping motor 45 will cause the capstan wheel 8 to rotate in a series of discrete steps and thus electrode wire 2 will be pulled in a corresponding series of discrete steps through the plastics conduits 33, 37. The electrode wire 2 is fed through a guide conduit 46 mounted in the housing 21 and from there into an outlet port 47 mounted on the housing 21. From the outlet port 47 the wire is then guided to a welding head.

As has been previously mentioned, the bar 30 is pivotable about the pivot 31 from the position shown in Figure 3 to a position where the locating member 40 is spaced from the locating member 42. In use, the bar 30 is allowed to pivot freely so that as the size of the reserve loop 6 changes it will be accompanied by movement of the bar 30. This provides a convenient way in which to sense the size of the reserve loop 6 since movement of the reserve loop 6 causes corresponding movement of the bar 30. In this example, a linear transducer 48 in the form of a potentiometer is pivotally mounted at 49 to the housing 20 and is also pivotally mounted at 50 to an ear 51 integral with the arm 36 of the bar 30. Thus, movement of the bar 30 about the pivot 31 will be sensed by the linear transducer 48 which is connected in an electrical circuit to be described below in order to carry out appropriate adjustment of the speed of the analogue drive 28.

It is possible with this apparatus to enable the electrode wire 2 to be automatically fed through the unit prior to use. A piston/cylinder arrangement (omitted for clarity) is connected

between the housing 20 and an ear integral with the arm 36 of the bar 30 (in a similar way to the linear transducer 48) and at start up the piston/cylinder arrangement is actuated to position the bar 30 in the position shown in Figure 3 with the locating member 40 within the locating member 42. In that position, electrode wire 2 can be fed into the unit through the entry port 22 and it will then be guided between the guide rollers 23, through the guide 27a, and between the capstan wheel 4 and the rollers 5 at which point the analogue drive feeds the wire 2 forward. The wire is then fed into the guide conduit 27b, through the plastics conduits 34, 37, through the locating members 40, 42, between the capstan wheel 8 and the rollers 9 (which only lightly contact the wheel 8), through the guide contact 46 to the outlet port 47. Once the electrode wire 2 has been fed through in this way, the piston/cylinder arrangement is released and the arm 30 is then free to pivot about the pivot point 31. The spring 52 is connected between a part 53 of the housing 19 and a finger 54 of the arm 30 to cause the arm 30 to pivot in an anticlockwise direction so that once the piston/cylinder arrangement has been released the spring 52 will cause the arm 30 to pivot to an initial rest position. The pivoted arm 43 is then fixed (manually or automatically via means not shown) in a position where the electrode wire 2 is gripped between the rollers 9 and the capstan wheel 8.

Figure 7 illustrates a very simple circuit for use with the apparatus shown in Figures 3 to 5. In that circuit, the linear transducer 48 is shown connected across a power source 55 and in connection with a power amplifier 56 in series with the armature of the analogue drive 28. In a similar way to the operation of the circuit shown in Figure 2, movement of the arm 30 due to a change in the size of the reserve loop 6 will cause corresponding adjustment in the potentiometer of the linear transducer 48. Thus, if the reserve loop 6 increases in size, the resistance provided by the potentiometer between points 57, 58 will decrease causing the speed of the analogue drive 28 to decrease, thus allowing the reserve loop 6 to decrease in size towards its equilibrium position.

A modification in the construction of the arm 30 and the guide for the reserve loop 6 is illustrated in Figure 6. In this modification, a bar 30′ is provided pivoted at 31′. In this case, a guide housing 32′ is mounted on the opposite side of the pivot 31, from the bar 30′. Furthermore, a single continuous plastics conduit 59 extends along a substantially semicircular path between the guide housing 32′ and the locating member 40. The advantage of this arrangement over that shown in Figure 3 is that when the bar 30′ pivots about the pivot 31′, there is much less movement at the guide housing 32′ compared with the relative movement between the plastics conduit 34 and the guide conduit 27b in the Figure 3 example.

A further modification is illustrated in the Figure 6 example where the piston/cylinder arrangement 60 is mounted in the housing 20 on the opposite side of the bar 30′ from the linear transducer 48. The piston/cylinder arrangement 60 comprises a cylinder 61 in which a piston 62 is slidable and to which is connected a rod 63 the leading end of which supports a roller 64. At start up, the piston 62 is urged downwardly, as seen in Figure 6, against the force of a spring 65 so that the roller 64 pushes the arm 30′ in a clockwise direction until the locating member 40 engages the locating member 42. Electrode wire 2 is then fed through the unit as previously described whereupon pressure is released from the piston/cylinder arrangement 60 and the piston 62 moves upwardly to withdraw the rod 63 and the roller 64 to a rest position. Initially, as in the previous example, the electrode wire 2 is not gripped between the rollers 9 and the capstan wheel 8 so that in both examples when the bar 30 or the bar 30′ is released, the length of the electrode wire between each end of the bar 30 or the bar 30′ increases and, in the case of the example shown in Figure 6, this increase causes the bar 30′ to pivot to the position shown in phantom in Figure 6. This will be the initial rest position. The advantage of providing the piston/cylinder arrangement 60 is that in use there is no contact between the roller 64 and the bar 30′ whereas in the example shown in Figure 3, the piston/cylinder arrangement is always attached to the bar 30 and thus has some resistive effect.

Once electrode wire 2 has been fed through the unit, the arm 43 is moved to the position shown in Figure 4 so that the rollers 9 press against the capstan wheel 8. In some examples, the arms 25, 43 can be remotely actuated to enable free access for maintenance to the respective capstan wheels and also to enable the unit to be used in gas-tight feeding systems since no manual adjustment is needed.

Another example of apparatus is illustrated in Figures 8A and 8B. These drawings are only schematic to illustrate the principle of the apparatus. In this apparatus, a pinch roll feeder 66 comprises a capstan wheel 67 and a roller 68 between which an electrode wire 2 is gripped. The capstan wheel 67 is connected by means not shown to a conventional stepping drive. The apparatus also comprises a capstan wheel 69 connected by means not shown to an analogue drive which rotates the capstan wheel 69 at a constant speed. A "V" shaped groove 70 is provided around the perimeter of the capstan wheel 69 and in use the electrode wire 2 extends in a loop around the capstan wheel 69 in the groove 70. This loop 71 is the reserve loop. A retaining flange 72 is mounted around the perimeter of the capstan wheel 69 to retain the electrode wire 2 within the groove 70.

In use, the capstan wheel 69 is rotated at a constant speed which is set to provide a wire feed rate greater than the maximum demand of the pinch roll feeder 66 driven by the stepping motor. Initially, the electrode wire 2 will engage the

capstan wheel 69 so that rotation of the wheel 69 will draw wire from the store (not shown). If the amount of wire drawn from the store exceeds that demanded by the pinch roll feeder 66, the loop 71 (previously in engagement with the wheel 69) will expand and become free from the wheel 69 so that the tractive force exerted on the electrode wire 2 by the capstan wheel 69 will immediately cease, although the capstan wheel 69 will continue to rotate. When the pinch roll feeder 66 again demands wire, the loop 71 will gradually decrease in diameter until it again engages the capstan wheel 69 whereupon more wire will be drawn from the store. It should be apprecated that unlike the previous examples, no electronic feedback arrangement is required since the rotation speed of the capstan wheel 69 remains constant throughout. As with the previous examples, however, automatic feed arrangements using suitable guides can be provided.

Where there is a long distance from the wire store to the welding head it may be desirable to provide more than one capstan wheel 69 and associated reserve loops 71. Figure 9 illustrates such an example with three capstan wheels 69, 69′, 69″, the electrode wire 2 being wound around each capstan wheel to provide corresponding reserve loops 71, 71′, 71″. For the purposes of clarity, the retaining flanges 72 have been omitted in Figure 9. In order that the apparatus shown in Figure 9 can operate successfully, either the diameters of each capstan wheel 69, 69′, 69″ must successively increase with the diameter of capstan wheel 69 being smaller than that of 69′ which is smaller than that of 69″, or the diameters may all be the same but the speeds of revolution must successively increase with the rotational speed of capstan wheel 69 being less than that of wheel 69′ which is less than that of 69″. Either of these solutions will ensure that no breakage of the electrode wire 2 will occur. Again, as with the example shown in Figure 8A, no feedback circuitry to alter the speed of rotation of the capstan wheels 69, 69′, 69″ is required.

In use, this feed apparatus can be included in fully automatic welding apparatus with all the steps for feeding and welding pre-programmed into a remote control unit, particularly since it is possible with this apparatus to feed the electrode wire 2 automatically through the feeding apparatus at start up.

It may be desirable in some cases to position a tachograph downstream of the pinch roll feeder driven by the stepping motor in order to provide an accurate measure of the amount of wire fed for confirmation that no slip has occurred in applications requiring such quality assurance.

Claims

1. A method of supplying wire from a store to an arc welding site, the method comprising forming a reserve loop in the wire between the store and the welding site; and supplying wire from the store when the size of the reserve loop decreases in response to demand for wire at the arc welding site.

2. A method according to claim 1, further including sensing the size of the reserve loop and controlling the rate at which the wire is supplied from the store in response to the sensed size of the loop.

3. A method according to claim 1, substantially as described with reference to any of the examples shown in the accompanying drawings.

4. Apparatus for supplying wire to an arc welding site, the apparatus comprising an electrode wire store; and supplying means for supplying wire from the store, a part of the wire supplied from the store describing a reserve loop in use, whereby the supplying means supplies wire from the store when the size of the reserve loop decreases in response to demand for wire at the arc welding site.

5. Apparatus according to claim 4, further comprising means for sensing the size of the reserve loop and for controlling the rate at which wire is supplied from the store in response to the sensed size of the reserve loop.

6. Apparatus according to claim 5, further comprising a resistive element against which the reserve loop of wire is caused to rub in use, the resistive element being electrically connected to the means for supplying wire from the store, the means for supplying wire from the store being electrically connected to the electrode wire at a position spaced from the resistive element whereby a variable resistor or potentiometer is formed by the wire and the element, the position of the wire on the element determining the effective resistance or potential of the variable element and thereby controlling the speed of the means for supplying wire from the store.

7. Apparatus according to claim 5, wherein at least a portion of the reserve loop passes through a conduit which is movable in response to changes in size of the reserve loop, the conduit being coupled to means for sensing its position whereby the size of the reserve loop is sensed.

8. Apparatus according to any of claims 4 to 7, comprising a continuous drive for supplying wire from the store; and a step drive for feeding the wire to the welding site, the reserve loop being provided between the continuous drive and the step drive.

9. Apparatus according to claim 7 and claim 8, wherein the conduit is pivoted at one end and is movable to a first position so that on start up wire may be fed automatically from the continuous drive to the step drive, the conduit subsequently being pivotable away from its first position in response to changes in size of the reserve loop.

10. Apparatus according to any of claims 4 to 7, wherein the means for supplying wire from the store comprises a continuous drive positioned adjacent the reserve loop, the arrangement being such that when the size of the reserve loop decreases in response to demand for wire at the arc welding site the reserve loop engages the

continuous drive whereby wire is drawn from the store.

11. Apparatus according to claim 10, wherein the means for supplying the wire from the store comprises a plurality of continuous drives, the electrode wire being guided through a corresponding plurality of reserve loops adjacent respective ones of the drives.

12. Apparatus according to claim 10 or claim 11, wherein the or each continuous drive has a V-shaped driving surface which engages and guides the wire in use.

13. Apparatus according to any of claims 10 to 12, wherein the or each continuous drive comprises a capstan feeder, the reserve loop being formed around the capstan of the capstan feeder.

14. Apparatus according to any of claims 4 to 13 for use in spacer welding apparatus, the apparatus including a step drive mounted on a robot arm for feeding the wire to the welding site.

15. Apparatus according to claim 4, substantially as described with reference to any of the examples shown in the accompanying drawings.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1983. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.